

CLAIMS

What is claimed is:

1. An apparatus for heating a flowable material comprising:

a core having a passageway formed therein for the communication of the flowable material, the core having an outer surface; and

an electric element coiled in multiple turns against the core in a helical pattern, the electric element, in use, heating the core both resistively and inductively, the electric element having no auxiliary cooling capacity.
2. The apparatus of claim 1, wherein the outer surface of the core has at least one helical groove which receives the electric element.
3. The apparatus of claim 2, wherein the electric element has a conductor that is surrounded by an electrically insulative material that is also thermally conductive, and a metallic sheath around the insulative material.
4. The apparatus of claim 3, wherein the conductor is made of a nickel chromium alloy.
5. The apparatus of claim 3, wherein the groove has a contour and wherein at least a portion of the sheath conforms to the contour.
6. The apparatus of claim 5, wherein the groove has substantially vertical walls which cooperate with the sheath to retain electric element in the groove.
7. The apparatus of claim 2, wherein the groove is sufficiently deep such that an outer surface of the electric element is approximately even with the outer surface of the core.

8. The apparatus of claim 7, further comprising a yoke disposed around the core.

10. The apparatus of claim 8, wherein the core and the yoke are made of ferromagnetic material.

11. The apparatus of claim 8, wherein the yoke comprises a sleeve fitting tightly against the electric element.

12. The apparatus of claim 11, wherein the sleeve is substantially thinner than the core.

13. The apparatus of claim 11, wherein the sleeve is approximately the same thickness as the core.

14. The apparatus of claim 1, wherein an outer surface of the electric element extends beyond the outer surface of the core.

15. The apparatus of claim 14, wherein the outer surface of the core has at least one helical groove which receives the electric element.

16. The apparatus of claim 14, further comprising a covering made of a metallic alloy deposited on an outer surface of the electric element and the outer surface of the core.

17. The apparatus of claim 14, further comprising a spacer element applied between each turn of the coiled electrical element.

18. The apparatus of claim 17 wherein the spacer comprises an annealed ferromagnetic alloy.

19. The apparatus of claim 17, further comprising a sleeve installed over the core with the electric element and the spacer element disposed around the core

so that the spacer element and electric elements are contained between the sleeve and the core.

20. The apparatus of claim 1, wherein the electrical element is deposited on the outer surface of the core, electric element comprising a first insulating layer applied to at least a portion of the outer surface of the core, a heating element deposited in a helical pattern on the first insulating layer, and a second insulating layer deposited over the heating element to encapsulate it.

21. The apparatus of claim 20, wherein the second insulating layer is finished to be flush with the outside surface of the core.

22. The apparatus of claim 22, further comprising a sleeve installed over the core.

23. The apparatus of claim 20, wherein the core has a helical groove on the outer surface and the electric element is deposited in a helical groove.

24. The apparatus of claim 20, wherein a plurality of electric elements are deposited to form a multilayered coil.

25. An apparatus for heating a flowable material comprising:
a core having a passageway formed therein for the communication of the flowable material, the core having an inner surface and a wear-resistant liner adjacent the inner surface; and
an electric element coiled in multiple turns against the core at the inner surface of the core, the electric element, in use, heating the core and liner both resistively and inductively, the electric element having no auxiliary cooling capacity.

26. The apparatus of claim 25, wherein the electric element is embedded in the liner and the liner comprises a covering made of a metallic alloy deposited on an inner surface of the electric element and the inner surface of the core.

27. The apparatus of claim 26, wherein the liner is finished to form a smooth bore through which the flowable material passes.